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THE HANGING ROCK REGION.

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The Hanging Rock iron region of Southeastern Ohio and Northeastern Kentucky is one of the oldest iron smelting districts west of the Allegheny Mountains, and now one of the principal charcoal iron regions in the United States. The title has been given to the region from the village of Hanging Rock, in Lawrence county, Ohio, near which place, as has already been observed, the industry was begun in 1826, and which also was formerly the chief point of shipment for the irons produced by the furnaces of the vicinity. The area so named is included in a narrow belt of territory, having an extension in nearly a north and south direction, with a width on the Ohio River of between 12 and 15 miles, where Ironton may be regarded as situated centrally as regards its east and west limits. In Kentucky this belt has probably an extension of 25 or 30 miles to the south, passing through the counties of Greenup, Carter, Boyd and Lawrence. In Ohio, extending through Scioto, Lawrence, Gallia, Jackson and Vinton counties, to the central part of Hocking it has a length northward of the Ohio River of between 65 and 70 miles, the broadest part of the area resting on the Ohio. Within a radius of 25 miles from Ironton, which is about the geographical center of the region, is included the most important part of its iron industry, both in Ohio and Kentucky. We are concerned here, however, only with that part of the area in the State of Ohio, but most of the observations concerning the character and occurrence of the ores, and the conditions of the manufacture in Ohio apply almost equally well to that part of the region in Kentucky.

The source of the reputation, the wealth and the industry of this Hanging Rock iron region are the rich iron ore deposits lying in several strata near the base of the Coal Measures, and which extend with great uniformity and regularity through the area described. These same ferriferous horizons, however, are quite well marked over the entire area of the coal fields in Ohio, and in the northeastern part of the State are probably represented by the ferriferous horizons of coals No. 3 and No. 4, which are in places in the northern part of the State of some economical importance. In Northwestern Pennsylvania the belt of the celebrated ferriferous limestone has been regarded as the equivalent of these same horizons. Ohio has, however, the most important concentration of iron ore at these levels in the southern part of the State, and no very valuable quantities have been found north of the Licking River. The abundance and accessibility of these ores in the Hanging Rock region, and the generous supply of fuel in its extensive forests have furnished materials for an iron industry which was represented in Ohio in 1870 by 34 charcoal furnaces, producing 83,900 tons, and 3 stonecoal and coke furnaces, producing 28,000 tons.

The list of the furnaces, showing their distribution and dates of establishment, will exhibit very well the progress and present importance of the iron industry of this region. The Hanging Rock charcoal iron has long possessed a very high reputation in all the western markets for its great purity and fitness for casting purposes demanding strength. Thus it has been the most favored iron at Pittsburgh for the fabrication of ordnance for the Government, and is now specially valued for the manufacture of car-wheels, and for producing superior grades of malleable iron.

The disappearance of the forests under the demands of the furnaces, which is now so apparent throughout the region, increases every year the difficulty of obtaining the necessary fuel, and marks very plainly the fate of the charcoal iron industry. The large amount of wood necessary to sustain a blast-furnace may be appreciated when it is known that some 13,000 cords of wood, the yield of 325 to 350 acres of forest land, are required per year for each furnace. And already a number of furnaces have been abandoned because of the scarcity of accessible timber, though the supply of ore has hardly been much diminished. The use of charcoal must

yield, as it has done in all other parts of the State, and is now doing in other States, to the more extended employment of mineral fuel. The manufacture of charcoal iron, nevertheless, will be a matter of considerable importance for some time to come, and the fine quality and high value of the iron will do much to foster its production. That the adoption of any systematic course of timber-growing, to replace the wood consumed, as is done in Sweden and Russia in localities deficient in mineral fuel, is not to be expected in a country like Ohio, where there are such vast stores of coal, and where the land must be of so much greater value for agricultural purposes. Economy and intelligent management will do much to prolong the life of a charcoal iron industry, but the increasing value of the furnace tracts, which are sometimes 10,000 to 12,000 acres in extent, must reduce the profits of the manufacture. These vast tracts of furnace property, embracing the larger part of the region, held as they are by a few proprietors for their timber supply, have to a great extent been passed over in the general settlement and cultivation of the neighboring portions of the State. And these circumstances have also prevented as thorough a knowledge of the resources of the region in coal, etc., as would have otherwise been the case. The region is about as thinly populated, and, excepting the Ohio Valley, as isolated and poorly provided with means of transportation as any portion of the State. The population is almost entirely dependent, directly or indirectly, upon the iron industry, over a large part of Lawrence county.

The surface of the country in the Hanging Rock region is, like so much of the eastern part of the State, a constant alternation of high hills and deeply eroded valleys, which have been cut out of the originally level surface of the State by the numerous streams which empty into the Ohio. The valleys cutting down through the various strata of rock, coal, iron ores, etc., present outcrops of these beds in positions scarcely surpassed for their accessibility to the miner. And water, though it has been the first miner in cutting out the beds formerly spanning the valleys, has been, nevertheless, a very wasteful one. As the strata all have a dip quite uniform and gentle toward the east, never greater than 30 feet per mile, the ores, coals, etc., which on the eastern side of the region are at or below the bottoms of the valleys, as we go

westward, rise until their proper position passes over the summits of the highest hills. Thus the region is limited on the east by the depth of the ores, rendering them difficult to win, and on the west by their absence from the tops of the hills, while between these limits the ores appear on the hill-sides at various elevations.

Allusion has already been made to the great extent of some of the furnace properties, which has prevented the general settlement of the country, and to a great extent its cultivation, and has scattered the points of the manufacture through the region at places more or less removed from one another, excepting, however, the few towns where industries depending on pig-iron have been established, and where the use of mineral fuel has rendered the community of industries more practicable.

Mention may be made here of the towns most important in the manufactures of the region and their means of communication. First—Jackson, in Jackson county, where the excellent "Jackson block coal" or the "shaft" coal is the basis of quite flourishing smelting establishments. At this place the Orange Furnace was the first furnace in the region where raw coal was used with continued success, and where it has been employed since 1866. There are now in Jackson four blast-furnaces using this fuel, and the native ores of the region, viz., the Star, Fulton, Globe and Tropic, all the result of the enterprise of the vicinity, but they are of quite moderate dimensions. Second—Portsmouth on the Ohio, at the mouth of the Little Scioto River, and beyond the western margin of the Coal Measures. Though containing two large rolling-mills, foundries, etc., it is more important as the chief commercial town of the region than as a manufacturing center. Being the terminus of the Portsmouth branch of the Cincinnati and Marietta Railroad, Portsmouth is the shipping place and business center of a large number of furnaces in the western part of the iron region. As almost every article of supplies necessary for the maintainance of the furnace population is derived from the adjoining parts of the State, the Scioto Valley, etc., the return trade is of very great importance, and in this, Portsmouth is the chief market of the region. Third—Ironton, in Lawrence county, 30 miles up the river from Portsmouth, in 1871 a city of 7,000 inhabitants, is the most important and enterprising manufacturing point in Southern Ohio, besides being the shipping and distributing center for the most

important part of the Hanging Rock region in Ohio. It is the largest town on the Ohio River above Cincinnati which has navigation uninterrupted by the fluctuations of the height of the water.

The general position of the iron ores of the region has already been referred to. Very detailed sections, showing their relative positions, may be seen in the reports of the included counties by Prof. Andrews in other portions of the Geological Reports, but a short notice may, however, be given here of the situation, character and mode of mining of the principal ores.

All the principal ores are found within 300 feet of the base of the Coal Measures, and the most important horizon, as regards the value of the ore and the persistency of its development, the horizon of the "limestone ore" has already been mentioned as the probable equivalent of the ferriferous limestone of Northwestern Pennsylvania.

The ores are limonites or hydrous peroxides of iron, and to a smaller extent, calcareous and argillaceous carbonates. The beds were, however, in their original condition as ores, probably all carbonates, but the oxidizing action of water and atmosphere has changed them, wherever such action was possible, into hydrous peroxides or limonites. The mining only exceptionally being more than stripping off the outcrop, the part of the beds beyond the action of oxidation where the iron is as a carbonated base furnishes but a small proportion of the ores obtained.

There are four perfectly distinct and persistent seams of ore, varying from 4 to 16 inches in thickness, beside several accumulations of kidney ore in the accompanying beds of shale. The main beds of ore are the "*Limestone ore*," the "*Big Red Block ore*," the "*Sand Block ore*," and the "*Little Red Block ore*." Also in the shales above the limestone ore, nodules or kidneys of argillaceous iron ore are found, which often become very abundant. At different horizons in the region are found other strata of shale which sometimes contain quite important amounts of this kidney, generally, however, at a higher level, and commonly known as "top hill ores." These nodules of kidney ore are never of sufficient abundance to warrant regular mining operations.

The *limestone ore* is by far the most important one of the series, both in richness and quantity, and the one from which two thirds of the iron is made in the region. Its name arises from its posi-

tion, overlying a limestone which is one of the most well-marked and persistent features in the geology of the region. This limestone, used constantly as a base line in surveying, furnishes the flux for the furnaces of the region, and is traceable across the Ohio into Kentucky, and northward into Northern Ohio. The limestone ore is found in its original state of a carbonate of iron, but mining operations along its outcrop have developed it mostly as a dark red hydrous peroxide or limonite, lying on the limestone in a regular bed, averaging about 12 inches thick, although in one or two instances basins have been found five feet in thickness. The "red limestone" is the richest and most valued ore, and contains on an average about 40 per cent. of metallic iron. It is the most important and widely used ore in the region, and the one more than any other upon which the high reputation of the Hanging Rock irons has been dependent. Without the "red limestone" ore in some proportions, there is little iron made in the region, and those furnaces producing the best quality of pig-iron use it almost exclusively. The ore varies in character from a hard compact limonite ore to one soft and ochreous, and frequently the mass has hard curling bands running through it which give rise to the name of "curly ore." The red limestone is quite pure, containing on an average about 10 per cent. of silica, and the amount of lime and alumina is never very large in the clean ore. Manganese is present, on an average, something more than 1¼ per cent., which, however, is scarcely a proportion large enough to affect the quality of the iron directly. Sulphur is present in very small quantities, and in the mean of many analyses rarely exceeds $\frac{3}{100}$ of one per cent. Phosphorous, however, is most always present, and is the most considerable of the damaging impurities, there being on an average about three-tenths of one per cent.

The "red limestone" ore extends into the hills to a depth depending upon its position and the character of the overlying rocks as regards their imperviousness to the action of water, and passes into the unchanged carbonate ores, which was probably the original condition of the entire stratum. The extent of the change varies considerably, as sometimes the limonitic or red limestone variety prevails, while at other times the change has not been so extended and the carbonates are more abundant. The mining operations, however, having been mostly confined to the outcrops

of the seam, the carbonate has always been obtained in smaller proportions than the oxidized or "red limestone" part. This ore is a carbonate more or less calcareous, and the analyses made contain rarely more than 8 or 10 per cent. of the carbonates of lime and magnesia, and in the clean ore but very small proportion of alumina. Very frequently it passes almost imperceptibly into quite a pure limestone containing scarcely any iron at all. It is found in two varieties—the gray and blue limestone ores. The gray limestone ore is somewhat oolitic in character, being formed of a mass of granules of carbonates of iron cemented together by a calcareous and silicious cement, which, on exposure to the weather, softens and crumbles. When burnt, however, the carbonate is oxidized, the mass becoming of a brick-red color, and though being more difficult to calcine than the other ores, is highly valued for the ease with which it works in the furnace and the character of the iron produced. The blue limestone ore is a more uniform calcareous ore of the limestone seam, quite hard and compact, and not unfrequently passing into a limestone containing little or no iron. These unchanged "limestone" ores vary somewhat in the iron contained, which is by analysis from 28 to 30 per cent., the blue limestone ore usually being the richer, when roasted they are reported to yield about 40 per cent. of pig-iron. They contain less phosphoric acid, but usually more sulphur than the "red limestone" portion of the seam, and as mixture they are found to work excellently in the furnace, and to a certain extent are self-fluxing from the lime and alumina contained. In places the limestone seam of ores is largely composed of rounded masses or kidneys, all the varieties being found in such condition as the "red limestone," "gray limestone," and blue limestone kidneys already mentioned. From the rising of the strata, as one passes to the west part of the region, it follows that the limestone ore rises and eventually is wanting entirely in the hills. Thus there is but little limestone ore obtained on the west side of the Portsmouth branch of the M. & C. R. R. from Hamden southward, while in the central and eastern part it is almost the exclusive ore. This is the only seam of ore in the region upon which any regular mining operations have been conducted, and the seam being only about 12 inches thick, it requires considerable skill in its extraction. The Hecla Furnace Co., in the central part of Lawrence county,

have for some 10 or 15 years pursued quite extensive mining operations by drifts and shafts, and this method of extraction is necessarily becoming more extended.

The Block ores are of much less importance than the ores of the limestone seam already mentioned, and lying beneath this stratum at different depths, from 50 feet and more, are accessible only in the valleys of the western part of the region. They are limonite ores containing from 30 to 40 per cent. of iron, but are chiefly characterized as being more or less silicious. The name "Block ore" arises from the strata being cut by vertical seams, which divide it into blocks of quite regular shapes. Each of these blocks is oxidized in concentric layers, giving the ore a banded appearance around a central nucleus, which is often hollow and sometimes is filled with soft ochre or clay. Three beds of these block ores have been recognized. The first is the "Big Red Block" ore, from 6 to 18 inches in thickness, and about 100 feet below the limestone seam. The second, the "Sand Rock" ore, about 6 inches in thickness, is about 20 feet below the "Big Red Block," and is generally more silicious in character and poorer in iron than the others. Below this, about 40 feet, is the "Little Red Block" ore, in a seam about 4 inches in thickness, and is usually somewhat richer in iron than the "Big Red Block," to which it is quite similar.